In Association with

Geotechnical Instrumentation Plan for MP 07.90R Area

WSDOT I-405 Renton to Bellevue Design-Build

Renton to Bellevue, Washington

Project # PS19-20316-0

Prepared for:

Flatiron-Lane Joint Venture

Prepared by:

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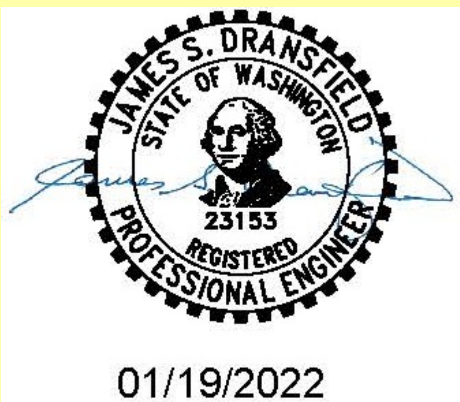

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CPF	Concrete Protection Fence
EOR	Engineer of Record
Flatiron-Lane	Flatiron-Lane Joint Venture
GIP	Geotechnical Instrumentation Plan
I-405	Interstate 405
MP	mile post
RFP	Request for Proposal
Wood	Wood Environment & Infrastructure Solutions, Inc.
WSDOT	Washington State Department of Transportation

1.0 Introduction

This Geotechnical Instrumentation Plan (GIP) was prepared by Wood Environment & Infrastructure Solutions, Inc. (Wood) in support of the Washington State Department of Transportation (WSDOT) Interstate 405 (I-405) Renton to Bellevue Design-Build project, in accordance with the requirements presented in the I-405 Renton to Bellevue Widening Project Request for Proposal (RFP), specifically Section 2.6.7.5, and the applicable sections of the WSDOT *Geotechnical Design Manual* (WSDOT 2015). The Project Geotechnical Design Manual consists of WSDOT's 2015 *Geotechnical Design Manual*, along with project-specific Chapters 6 (Seismic) and 15 (Retaining Walls) from the RFP Addendum 9.

This GIP is for the area at mile post (MP) 07.90R in Segment 1B. Specifically, this area extends from MP 07.90 to MP 08.30. The MP 7.90R area has been highlighted to have the potential for future landslides. Table 2 of the Geotechnical Baseline Report (WSDOT 2018a) identifies wall 7.90R and Noise Wall East 10 in the risk category for slope instability. The General Geologic Characterization and Unstable Slope Evaluation report (WSDOT 2018b) identifies prehistoric landslide deposits at MP 7.96 to 8.02. According to the report:

> "*…this ancient landslide was partially reactivated following original highway cut slope construction and was partially mitigated by a rock buttress. Heavy seepage from this slope is ongoing. Cuts are to be made into this slope and a retaining wall will be constructed across this landslide feature. The design of this retaining wall should account for potential landslide forces acting against the wall. The construction of this wall should consider stability of the temporary slopes if the rock buttress is removed from the toe of the landslide. If the existing rock buttress requires excavation or removal in order to construct the new retaining wall, consideration should be given to slot-cutting, shoring, or otherwise mitigating the potentially unstable temporary slope that would be excavated above I-405 during construction*."

This GIP is intended to monitor the subject slope for the earthwork associated with site grading and construction of walls in the area of MP 07.90R, which includes retaining walls 07.90R-A (1), (2) and (3), 07.90R-B and 07.90R-C, as well as Noise Wall East 10 (1) and (2) and Concrete Protection Fence (CPF). The proposed locations of instruments are provided in the plans, profiles, and cross sections in Appendix A.

Approximate locations for slope inclinometers for each of the retaining walls are shown in Appendix A. The slope inclinometers are proposed behind each retaining wall in areas with historical landslides or in areas with the potential for landslides based on the topography and subsurface soil conditions. Three existing slope inclinometers will also be monitored as part of this GIP; however, new inclinometers are proposed as the existing inclinometers are further up the slopes and may not capture issues at the retaining walls. Optical monitoring points will also be placed on the new retaining walls following construction. Houses are located upslope of some of the retaining walls and survey prisms are recommended on the houses.

2.0 Requirements for Geotechnical Instrumentation Plan

Section 2.6.7.5 of the I-405 Renton to Bellevue Widening Project RFP requires that geotechnical instrumentation shall be installed and used to monitor the following:

1. Sensitive facilities;
2. Temporary shoring;
3. Settlement and settlement rates on embankments and structures where settlements are predicted to be more than 2 inches;
4. Pore water pressures for staged embankment construction;
5. Groundwater levels (if dewatering is used);
6. Ground and structure vibrations when impact or vibratory methods are used for installation of shaft casings or driving piling; and
7. Vibration levels for freshly placed concrete in conformance with Section 6-02.3(6)D of the Standard Specifications (WSDOT 2018c).

Based on our understanding of the landslides at this location, Condition 1 above should be addressed with instrumentation. Dewatering is not anticipated during clearing/grubbing/stripping operations associated with site grading. Ground and structure vibrations from installation of shaft casing or pile driving are not expected to occur due to the use of drilled shafts for the installation of the soldier piles. Assuming concrete is placed in conformance with Section 6-02.3(6)D of the Standard Specifications (WSDOT 2018c), vibration monitoring is not anticipated to be required due to placing concrete.

3.0 Geotechnical Instrumentation Plan

The GIP for the MP 7.90R area shall consist of slope inclinometers, optical monitoring points, and survey prisms placed at locations described in the GIP. Slope inclinometers should be installed at depths below the subsurface layers with landslide potential. The proposed locations and elevations of the slope inclinometers are shown in Table 1, as well as in Appendix A. Wood selected the location of the slope inclinometers based on the locations of historical landslides and the locations of areas with subsurface conditions with the potential for landslides. One inclinometer is proposed behind each retaining wall (07.90R-A [1], [2], and [3]; 07.90R-B; and 07.90R-C). The location of each inclinometer at the walls was chosen to investigate the most critical landslide areas based on the historical information and the locations of the retaining walls. The slope inclinometers can be relocated from the proposed locations in the field, depending on site conditions and anticipated construction activities. The monitoring locations can be relocated up to 10 feet in the longitudinal direction and up to 5 feet in the perpendicular direction to the wall/barrier without approval from the Geotechnical Engineer of Record (EOR). Deviations greater than these limits shall be approved by the Geotechnical EOR. The locations of the slope inclinometers will be shown on the final construction plan sheets.

Details regarding the depth, elevation, and locations of the proposed slope inclinometers, as well as detailed regarding the existing WSDOT slope inclinometers are presented in Table 1.

Table 1: Slope Inclinometer Locations for MP 07.90R Area

Slope Inclinometer	Station	Offset East of I-405 Center Line (feet)	Proposed Depth Below Grade (feet)	Proposed Bottom Elevation (feet)
R2B-47si-17[1]	7721+18.56	103.2	110.5	15.4
R2B-51si-17[1]	7727+05.203	96.8	76.5	46.7
R2B-55si-17[1]	7737+69.31	93.2	84.5	46.4
SI-1-7.90R-A	7720+21.21	70.00	35	55
SI-2-7.90R-A	7722+77.36	70.33	41	60
SI-3-7.90R-A	7728+43.68	72.88	43	70
SI-1-7.90R-B	7732+23.99	53.96	34	73
SI-1-7.90R-C	7735+38.66	69.75	41	70

<u>Note:</u>
1. Slope inclinometer previously installed by WSDOT.

<u>Abbreviations:</u>
I-405 = Interstate 405
MP = mile post
WSDOT = Washington State Department of Transportation

Optical monitoring points shall also be placed on top of the finished retaining walls 07.90R-A (1), (2), and (3), 07.90R-B and 07.90R-C to monitoring for any movement of the retaining walls. Retaining walls 07.90R-A (1), (2), and (3) are soldier pile walls and monitoring points shall be placed on every other pile. Retaining walls 07.90R-B and 07.90R-C are soil nail walls and monitoring points shall be spaced no more than 25 feet apart for the length of the wall. Optical monitoring points shall also be placed on Noise Wall 10 East (1) and (2) and the CPF. It is expected that the noise walls and CPF will be installed using drilled shafts. The optical monitoring points should be placed on every other shaft. Alternatively, a FlatMesh Triaxial Tilt Sensor Node that communicates through a wireless monitoring system can be used. The monitoring will be continuous with an equipment accuracy of 0.01 foot (0.12 inch).

Due to the anticipated construction sequence, the optical monitoring points on soil nail walls 07.90R-B and 07.90R-C will need to be replaced during construction. The monitoring points shall initially be installed on the shotcrete facing, following the installation of the top row of soil nails. A baseline reading will need to be taken on these points immediately after installation; following that, they shall be read as per Table 2 in Section 3.2. The permanent wall fascia will not be completed initially, as it is not critical to the structural capacity of the wall. However, post-construction monitoring is required to continue after the installation of the permanent wall fascia. These initial optical monitoring points will monitor post-construction movement.

Once permanent wall fascia is completed, these optical points will be covered and unusable, and another set of optical monitoring points shall be installed on the fascia. A second baseline reading of these points will need to be completed immediately after the installation of the points and then post-construction monitoring can continue as discussed in Section 3.2.

Houses are present within 70 feet of retaining walls 07.90R-A (1), (2), and (3). The houses appear to be two stories tall and have dimensions between 35x60 feet and 60x70 feet, and are located at elevations about 15 to 30 feet higher than the wall. The details of the foundation of the houses are not known at this time.

At least three prisms will be installed around the base of each exterior wall of each house. Additional survey prisms may be added at the discretion of Flatiron-Lane Joint Venture (Flatiron-Lane) based on the precondition survey described below. Using these prisms, the surveyor will take baseline vertical elevations, as well as horizontal northings and eastings, along with subsequent readings.

Flatiron-Lane crews will conduct a precondition survey of the exterior of the houses, as well as any pavement or driveways. Performance of this survey will be coordinated with WSDOT inspection staff. This survey will consist of the following steps:

1. Clear any debris from the sides of the house to obtain an unobstructed view of the exterior walls.
2. Take photographs and videos of the interior and exterior walls to document any pre-existing issues for future reference. Consider installing crack gages if any significant cracks are noted.
3. Inspect any pavement in the area of the houses and document any pre-existing issues for future reference.

This report will be provided to WSDOT for acceptance prior to the start of activity.

Flatiron-Lane crews will conduct the same survey described above after construction of walls 07.90R-A (1), (2), and (3) has been completed, to determine if any damage to the houses occurred as a result of construction.

Section 8.2 of Geotechnical Engineering Report: 07.90R-B Soil Nail Wall (Wood 2021) included a GIP for a house present about 30 feet east of the retaining wall. This house has been demolished since the report was completed, and therefore the GIP for the house is no longer applicable. All recommendations for the GIP in Section 8.2 of that report are no longer needed and are not included in this GIP.

A benchmark, located outside of the zone of influence of the MP 07.90R construction area, shall also be installed and monitored at the same frequency as the optical monitoring points. The monitoring points shall be compared to the benchmark to determine if the retaining walls show any movement.

Instruments that are damaged or fail for any reason of nonperformance shall be replaced immediately. If the instrumentation cannot be replaced immediately, construction activities within the zone of influence that were monitored by the instrumentation shall cease until the instrumentation is replaced and fully operable. The zone of influence is considered to be 25 feet horizontally from the center point of the instrument and the full height of the wall.

3.1 Slope Inclinometer Description

Slope inclinometers shall be constructed using standard slope inclinometer casings to the depths listed in Table 1. The casings should be grouted from the base of the inclinometer to the surface. If the inclinometers are finished above ground, they shall be protected by a steel casing extending at least 3 feet above the ground and 1 foot below the ground. If they are finished flush with the ground surface, they shall be protected by a steel casing extending at least 1 foot below the ground. Regardless of the installation method, they should be marked and protected from construction traffic to avoid any damage.

The inclinometers should be read every 2 feet up the entire length of the casing. A schematic sketch of a typical slope inclinometer installation is provided in Appendix B. Monitoring instrumentations shall be protected during construction with ecology blocks or traffic control devices. A temporary plate or lid should be used to protect the top of the pipe.

The slope inclinometers are likely to be placed within the layout of the soldier pile anchors or soil nails. The slope inclinometers will be installed first and should be placed in a location between the anchors or soil nails so they will not be damaged during the installation of the anchors and soil nails. Preplanning of the anchors and soil nails will need to take place to avoid damaging the slope inclinometers.

Any slope inclinometers present within the temporary construction easement shall be decommissioned after the post-construction monitoring and while the easement is still accessible. Slope inclinometers with the permanent right-of-way can remain following the completion of the post-construction monitoring. Prior to installation of the slope inclinometers, all rights of entry, permits, and environmental and archeological clearances necessary to perform the work shall be secured. The slope inclinometers shall be decommissioned in accordance with the provisions of applicable local Agency, State, and Federal laws and regulations.

To conduct the slope inclinometer readings, a recently calibrated probe shall be used, and the serial number and certification of the equipment shall be supplied to WSDOT and the Geotechnical EOR prior to any readings being taken. An addendum to this GIP will include the information once they are confirmed.

3.2 Monitoring Period and Frequency

During construction operations, instrument monitoring is required to assess the stability of the area. Post-construction monitoring is also required to ensure no movement is occurring following the completion of the earthwork in the MP 07.90R area. The monitoring frequencies are summarized in Table 2. The indicated frequencies should be considered as minimal and are subject to change depending on the actual response. Where unexpected results are measured, additional monitoring will be defined by the Geotechnical EOR.

Table 2: Monitoring Frequencies

Instrument	Pre-Construction Baseline Readings	During Construction	Post-Construction
Slope Inclinometers	Once[1]	Weekly[2]	Monthly for six months
Optical Monitoring Points	NA	NA	Weekly for six months[3]
Survey Prisms	Once[1]	Weekly[2]	Weekly for one month

Notes:
1. Taken prior to any construction of the retaining walls in the MP 07.90R area.
2. Only if construction is occurring in the vicinity of the inclinometer (i.e., SI-1-7.90R-A should be read during construction on retaining wall 07.90R-A [1]).
3. The first reading should be immediately after installation.

Abbreviations:
MP = mile post
NA = not applicable

After installation of the slope inclinometers and prior to any construction activity on the retaining walls or noise walls (i.e., after preconstruction activities such as access road construction, clearing and grubbing, etc.) in a given area, baseline readings are to be taken. In addition, one reading should be collected on the existing WSDOT inclinometers prior to construction. The optical monitoring points shall be installed and an initial reading shall be taken after installation of solider piles prior to proceeding with excavation.

Post-construction monitoring is defined as the period after the completion of all shotcrete/lagging work for all cut walls. Post-construction monitoring will continue for the 6-month period after these activities have been completed. Aesthetic and non-structural construction, such as fascia construction, can occur during this time frame.

The above frequencies are minimum requirements and may need to be adjusted based on the information collected. Before stopping measurements as described in Table 2, a series of three readings must show no appreciable change (verified by consultation with the Geotechnical EOR).

The Geotechnical EOR may change the frequency of the readings and the criteria for construction as data become available. Inclinometer and optical monitoring readings shall be provided to the Geotechnical EOR for evaluation and disposition once a week during this monitoring period.

Survey monitoring reports shall be provided to WSDOT on a monthly basis unless an Alert Level is triggered.

3.3 Alert Levels, Action Levels, and Corrective Action Plans

Section 2.6.7.5.1 of the RFP provides definitions of Alert Levels, Action Levels, and Corrective Action Plans, as defined below:

- Alert Levels represent the reading where increased scrutiny of the element is warranted and when the frequency of readings shall be increased;
- Action Levels represent the reading where corrective actions shall be implemented by the Design-Builder or the levels where work shall stop; and
- Corrective action plans are measures that can rapidly be implemented by the Design-Builder to decrease or stop detrimental stresses or strains.

3.3.1 Alert Level

The Alert Level for the inclinometers is when the maximum deflection in either direction exceeds 0.5 inch when compared to the baseline readings. Measured movements that exceed the alert level shall not be a cause to stop work; however, the contractor shall be made aware of the movements and alter the work plan to prevent further movement.

The Alert Level for the optical monitoring points is when the maximum movement, either in the horizontal or vertical directions, exceeds 0.5 inch within six months following the completion of construction. Measured movements that exceed the Alert Level shall not be a cause to stop work; however, the contractor shall be made aware of the movements and alter their work plan to prevent further movement.

The Alert Level of the survey prisms is when movement in any direction exceeds 3/16 inch when compared to the baseline readings. Measured movements that exceed the Alert Level shall not be a cause to stop work; however, the contractor shall be made aware of the movements and alter their work plan to prevent further movement.

If the Alert Level threshold is exceeded, monitoring of the exceeded instrument shall be increased to twice weekly. The Geotechnical EOR shall also review the construction procedures within 24 hours to determine if increased frequency of readings or other actions are required.

3.3.2 Action Level

The Action Level for the inclinometers is when the maximum deflection in either direction exceeds 1 inch when compared to the baseline reading within six months following the completion of construction. The Action Level for the optical monitoring points is when the maximum movement in either the horizontal or vertical directions exceeds 1 inch.

The Action Level of the survey prisms is when movement in any direction exceeds ¼ inch when compared to the baseline readings. Upon this notice, Flatiron-Lane will stop work and develop a corrective action plan to prevent further deformation and will perform a visual inspection of the houses or affected structures that will be submitted to the WSDOT Project Representative for review. This corrective action plan will be approved by the Project Representative before construction operation resume.

Measured movement that exceeds the Action Level shall trigger stoppage of work. At that time, the Geotechnical EOR will evaluate the impact on existing structures and determine an appropriate corrective action plan in accordance with Section 3.3.3.

3.3.3 Corrective Action Plan

A corrective action plan will be developed based on site circumstances in accordance with Section 2.6.7.5.1 of the RFP. The corrective action plans shall identify the steps to be taken if instrument readings reach an Action Level. At a minimum, these steps shall include the following:

- Identify where construction activity contributing to the Action Level shall be stopped based on the radius of influence identified for each significant activity.
- Notify the Geotechnical EOR with 24 hours of the data being collected.
- Revise the work plan.
- Provide revised work plan to WSDOT for review and comment.
- Stop work contributing to the monitoring exceedance and do not resume work until receiving the Geotechnical EOR's approval of the revised work plan.

- Identify circumstances where corrective actions may require modification of design or construction procedures.
- Require that if the approved revised work plan does not reduce the value below the critical instrument readings, all related operations contributing to the critical instrument reading shall cease and the process of developing a revised work plan shall be repeated.

The Geotechnical EOR will need to be consulted to determine where the movement is occurring and what actions may need to be taken. Examples of possible corrective actions may include regrading or fortifying areas of the slope to stabilize surficial soils, re-routing drainage. Additional measures such as longer tiebacks, additional tiebacks, or micropiles might be considered if deeper soils were to exhibit movement.

4.0 Reporting

Reports summarizing data collection (see example report in Appendix C) will be submitted to the Geotechnical EOR weekly and within one business day of collection, and a summary of monthly activity will be provided within the first week of the following month. The surveyor shall identify locations of benchmarks, located outside of the zone of influence, on the project plans. These reports will be posted to Procore and hard copies will be available as requested. These reports will include:

- A summary of the week's work that notes the work being performed, time that monitoring was conducted, and what work required monitoring;
- Observations that will help describe the monitoring for that week;
- A copy of the week's raw data (see example in Appendix C); and
- A graph representing the week's monitoring data.

Inclinometer and survey monitoring data will be transmitted on a monthly basis to WSDOT via email unless the Alert Level monitoring threshold is breached. The Construction Manager and Design Manager shall be notified verbally by the surveyor on the same day that the Alert Level monitoring threshold has been exceeded. WSDOT, the Construction Quality Assurance Manager, the Geotechnical Group Manager, and other relevant stakeholders shall be notified within 24 hours.

A Corrective Action Plan must be implemented by the Design-Builder when the Action Level monitoring threshold is exceeded. All construction must stop immediately until the Corrective Action Plan is implemented, and WSDOT, the Construction Quality Assurance Manager, the Geotechnical Group Manager, and other relevant stakeholders shall be notified within 24 hours. The Geotechnical EOR must approve restart of construction.

4.1 Equipment and Surveyor Qualifications

4.1.1 Equipment

The contractor shall furnish all labor and materials and perform all operations required for the installation, protection, and maintenance of the slope inclinometers and the optical monitoring points. All surveys will be performed at the frequencies defined in Section 3.2 of this document and to an accuracy of 0.01 foot (0.12 inch). A calibrated instrument shall be used and calibration certificates shall be provided. A permanent survey benchmark shall be established away from the construction zone prior to construction and shall be protected from construction equipment disturbance. The slope inclinometers will be within the construction zones and care should be taken to prevent damage to the instruments. The inclinometers should be read using the same slope inclinometer probe to the extent possible, in order to prevent any erroneous readings due to differences in equipment.

Results of the data collection shall be provided to the Wood Geotechnical Group Manager to determine if the survey should be continued and to review the frequency of monitoring. The data will be put into a report.

The equipment that is proposed to be used for the work consists of:

- Slope inclinometer probe;
- Trimble S7 1" Total Station or equivalent;
- Trimble DiNi Digital Level or equivalent; and
- As an alternative, FlatMesh Triaxial Tilt Sensor Nodes can be used in place of the optical survey.

Data sheets and calibration certificates for the survey equipment are presented in Appendix D.

4.1.2 Surveyor

The survey work will be conducted under the direction of Keith Craig Moore. Craig has more than 40 years of experience in the surveying field. His experience includes geometry control for fabrication and erection of precast concrete segments. Craig has held a supervisory position in the construction industry for 30 years. He has a record of success overseeing surveying on multimillion-dollar heavy civil, infrastructure, and commercial development projects for government and private-sector clients. Craig's resume is presented in Appendix E. Craig will be assisted in the field by:

- **Jay McCombs:** Jay's monitoring experience includes railroad monitoring for bridge installation, excavation shoring, building structure and foundation monitoring. Jay has 16 years of experience.
- **Trevin Sada:** Trevin has 30 years of experience and has performed monitoring for various types of balance cantilever bridges, excavation pile walls, railroad monitoring, public and private utilities, and various types of structures.
- **Sigurd Sorensen:** Sigurd has performed monitoring for high rise excavation and construction, settlement monitoring for mass grading, and long-term settlement monitoring. Sigurd has five years of experience.

At this time, the individual who will be responsible for completing the inclinometer readings is not known. Prior to any readings being taken, the Contractor shall provide the resume and qualifications of the individual prior to any readings of the instruments. The resume and qualifications will be included as an addendum to this GIP.

5.0 References

Washington State Department of Transportation (WSDOT). 2015. *Geotechnical Design Manual.* Publication M46-03.11.

WSDOT. 2018a. Geotechnical Baseline Report, I-405 Renton to Bellevue Widening and Express Toll Lanes Project. XL-4653/XL-5467, I-405, MP 0.0–14.6. December 14.

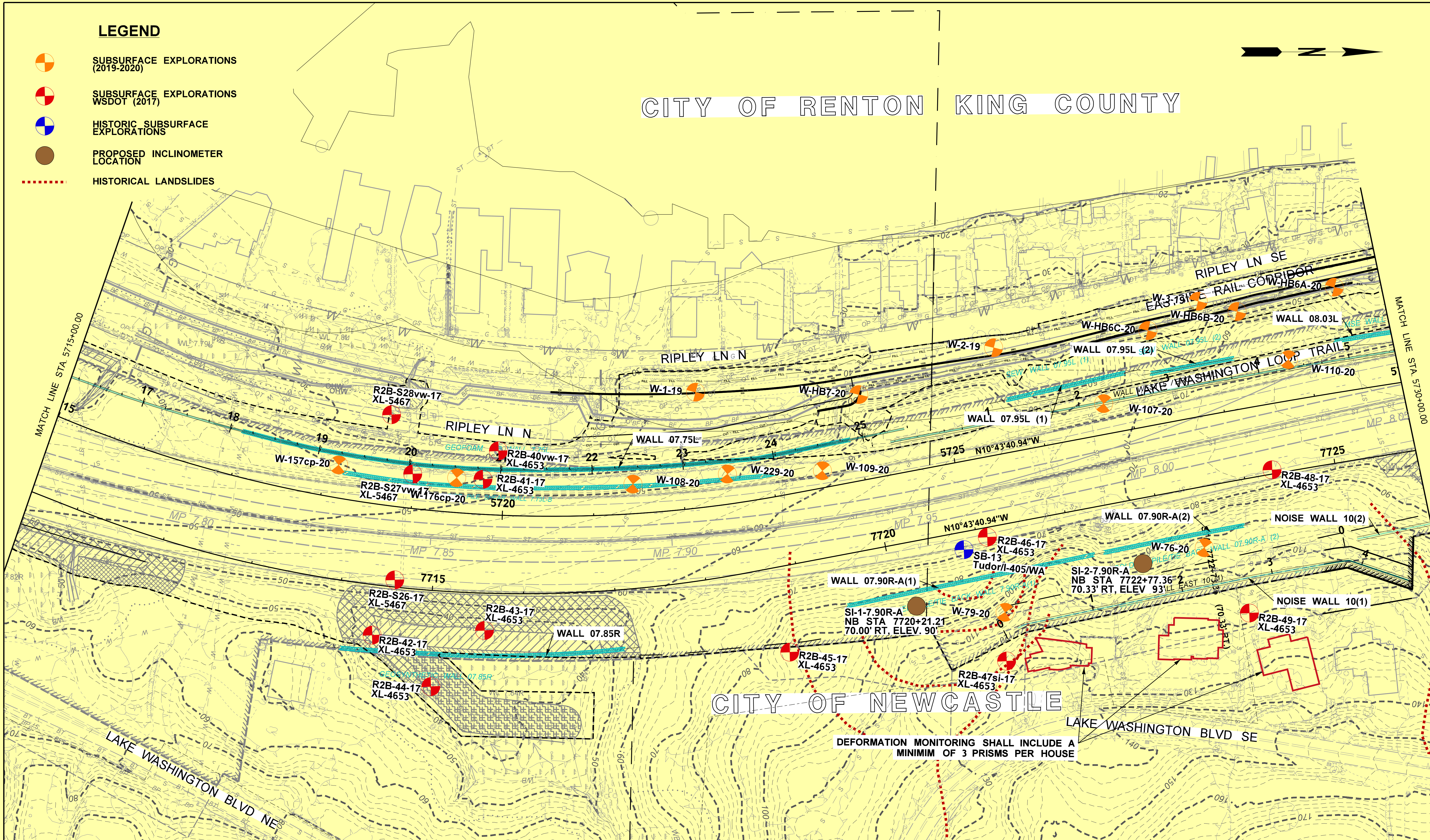
WSDOT. 2018b. General Geologic Characterization and Unstable Slope Evaluation, I-405 Renton to Bellevue Widening and Express Toll Lanes Project. December 14.

WSDOT. 2018c. *Standard Specifications for Road, Bridge, and Municipal Construction*. Publication M 41-10.

Wood Environment & Infrastructure Solutions, Inc. (Wood). 2021. Geotechnical Engineering Report: 07.90 R-B Soil Nail Wall. In association with Flatiron-Lane Joint Venture. April 20. Submittal No. 1292.

In Association with

Appendix A
Monitoring Locations



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REGIONAL ADM.	M. BOUCK		
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I-405; RENTON TO BELLEVUE WIDENING AND EXPRESS TOLL LANES PROJECT

GEOTECHNICAL INSTRUMENTATION PLAN
MP 07.90R AREA (1)

PLAN REF NO

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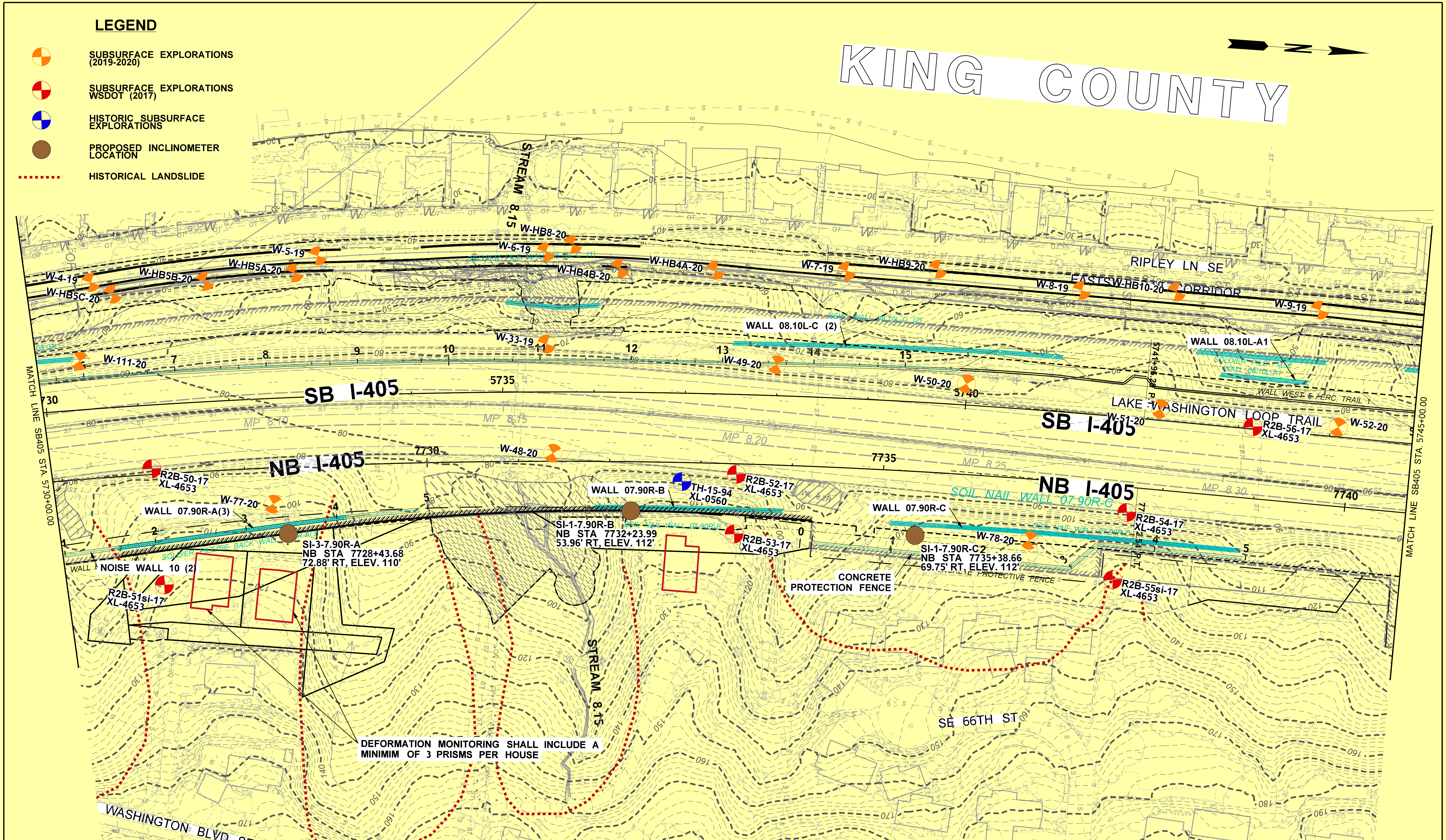

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Washington State Department of Transportation

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wood.

I-405; RENTON TO BELLEVUE WIDENING AND EXPRESS TOLL LANES PROJECT

GEOTECHNICAL INSTRUMENTATION PLAN
MP 07.90R AREA (2)

PLAN REF NO

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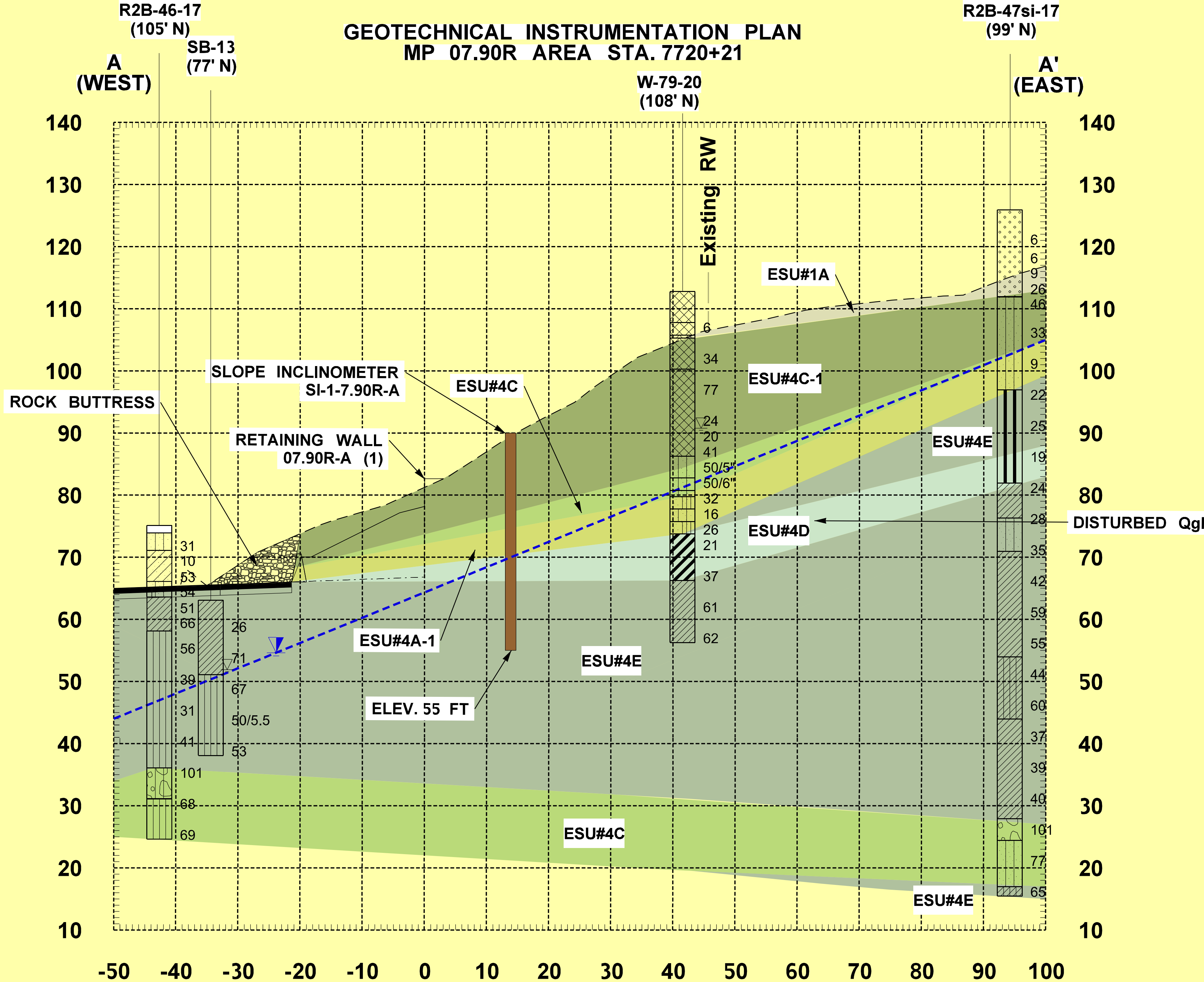
GEOTECHNICAL INSTRUMENTATION PLAN
MP 07.90R AREA STA. 7720+21



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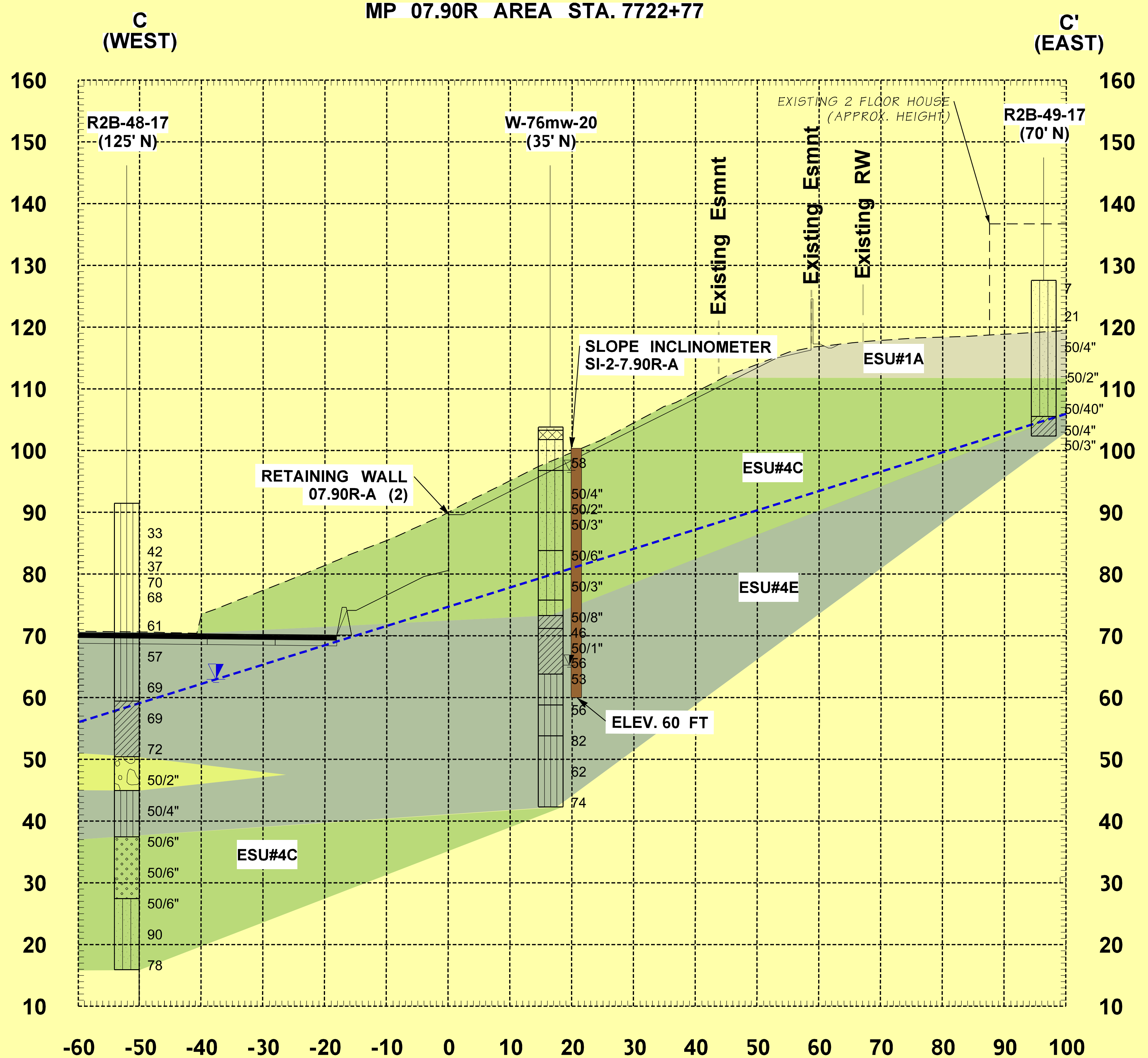
MP 07.90R AREA STA. 7722+77



THE ESU STRATIFICATION HAVE BEEN INTERPRETED, INTERPOLATED BETWEEN EXPLORATIONS, AND EXTRAPOLATED BEYOND EXPLORATIONS FOR ENGINEERING DESIGN PURPOSES. THE STRATA MAY NOT REPRESENT ACTUAL SUBSURFACE CONDITIONS. SEE THE EXPLORATION LOGS FOR DETAILED SUBSURFACE CONDITIONS AT THE LOCATION EXPLORED.

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PLOTTED BY	patrick.mccarthy
DESIGNED BY	A. PUSIC
ENTERED BY	P. MCCARTHY
CHECKED BY	M. RADIC
PROJ. ENGR.	T. WENTWORTH
REGIONAL ADM.	T. NETTLETON

REVISION | DATE | BY

REGION NO.	STATE	FED.AID PROJ.NO.
10	WASH	

JOB NUMBER

CONTRACT NO. | LOCATION NO.

DATE — P.E. STAMP BOX

DATE — P.E. STAMP BOX

Washington State Department of Transportation

FLATIRON LANE

wood.

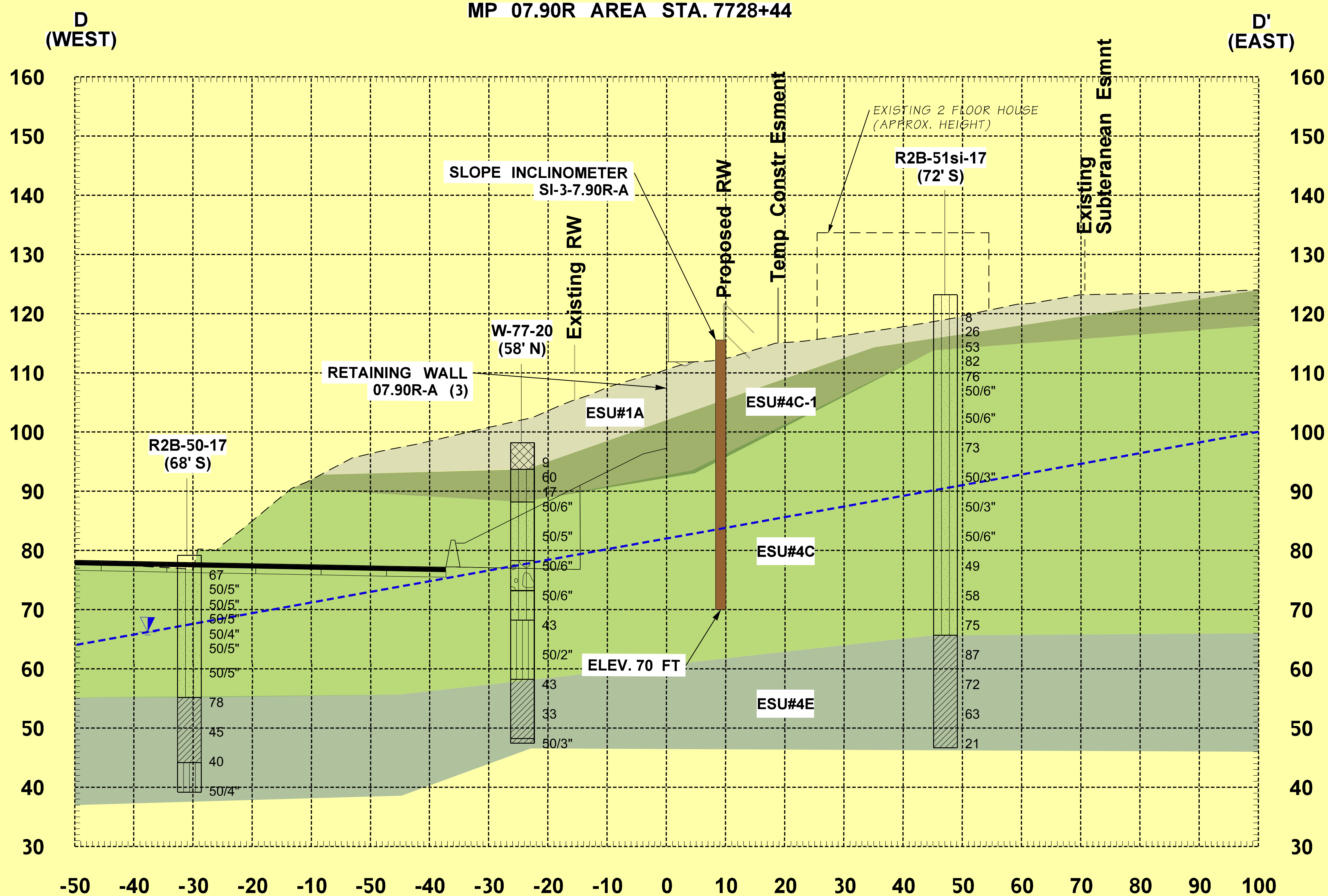
I-405; RENTON TO BELLEVUE WIDENING AND EXPRESS TOLL LANES PROJECT

GEOTECHNICAL INSTRUMENTATION PLAN
MP 07.90R AREA STA. 7722+77

PLAN REF NO

SHEET 4 OF 7 SHEETS

GEOTECHNICAL INSTRUMENTATION PLAN
MP 07.90R AREA STA. 7728+44



THE ESU STRATIFICATION HAVE BEEN INTERPRETED, INTERPOLATED BETWEEN EXPLORATIONS, AND EXTRAPOLATED BEYOND EXPLORATIONS FOR ENGINEERING DESIGN PURPOSES. THE STRATA MAY NOT REPRESENT ACTUAL SUBSURFACE CONDITIONS. SEE THE EXPLORATION LOGS FOR DETAILED SUBSURFACE CONDITIONS AT THE LOCATION EXPLORED.

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DESIGNED BY	A. PUSIC
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CHECKED BY	M. RADIC
PROJ. ENGR.	T. WENTWORTH
REGIONAL ADM.	T. NETTLETON

REVISION | DATE | BY

REGION NO.	STATE	FED.AID PROJ.NO.
10	WASH	

JOB NUMBER

CONTRACT NO. | LOCATION NO.

P.E. STAMP BOX DATE

P.E. STAMP BOX DATE

Washington State Department of Transportation

FLATIRON LANE

wood.

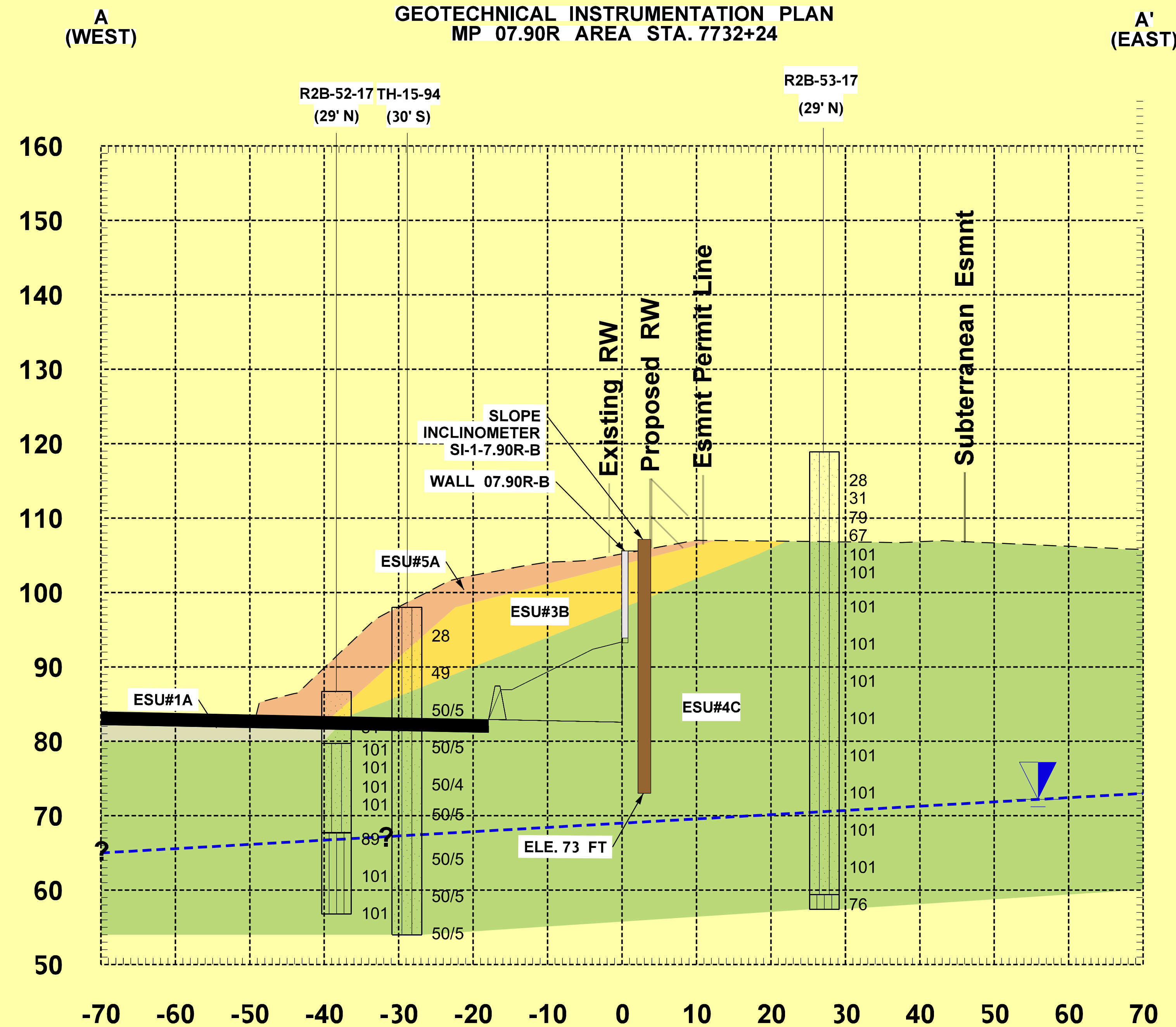
I-405; RENTON TO BELLEVUE WIDENING AND EXPRESS TOLL LANES PROJECT

GEOTECHNICAL INSTRUMENTATION PLAN
MP 07.90R AREA STA. 7728+44

PLAN REF NO

SHEET 5 OF 7 SHEETS

GEOTECHNICAL INSTRUMENTATION PLAN
MP 07.90R AREA STA. 7732+24



THE ESU STRATIFICATION HAVE BEEN INTERPRETED, INTERPOLATED BETWEEN EXPLORATIONS, AND EXTRAPOLATED BEYOND EXPLORATIONS FOR ENGINEERING DESIGN PURPOSES. THE STRATA MAY NOT REPRESENT ACTUAL SUBSURFACE CONDITIONS. SEE THE EXPLORATION LOGS FOR DETAILED SUBSURFACE CONDITIONS AT THE LOCATION EXPLORED.

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CHECKED BY	M. RADIC
PROJ. ENGR.	T. WENTWORTH
REGIONAL ADM.	T. NETTLETON

REVISION	DATE	BY

REGION NO.	STATE	FED.AID PROJ.NO.
10	WASH	
JOB NUMBER		
CONTRACT NO.		LOCATION NO.

P.E. STAMP BOX DATE

P.E. STAMP BOX DATE

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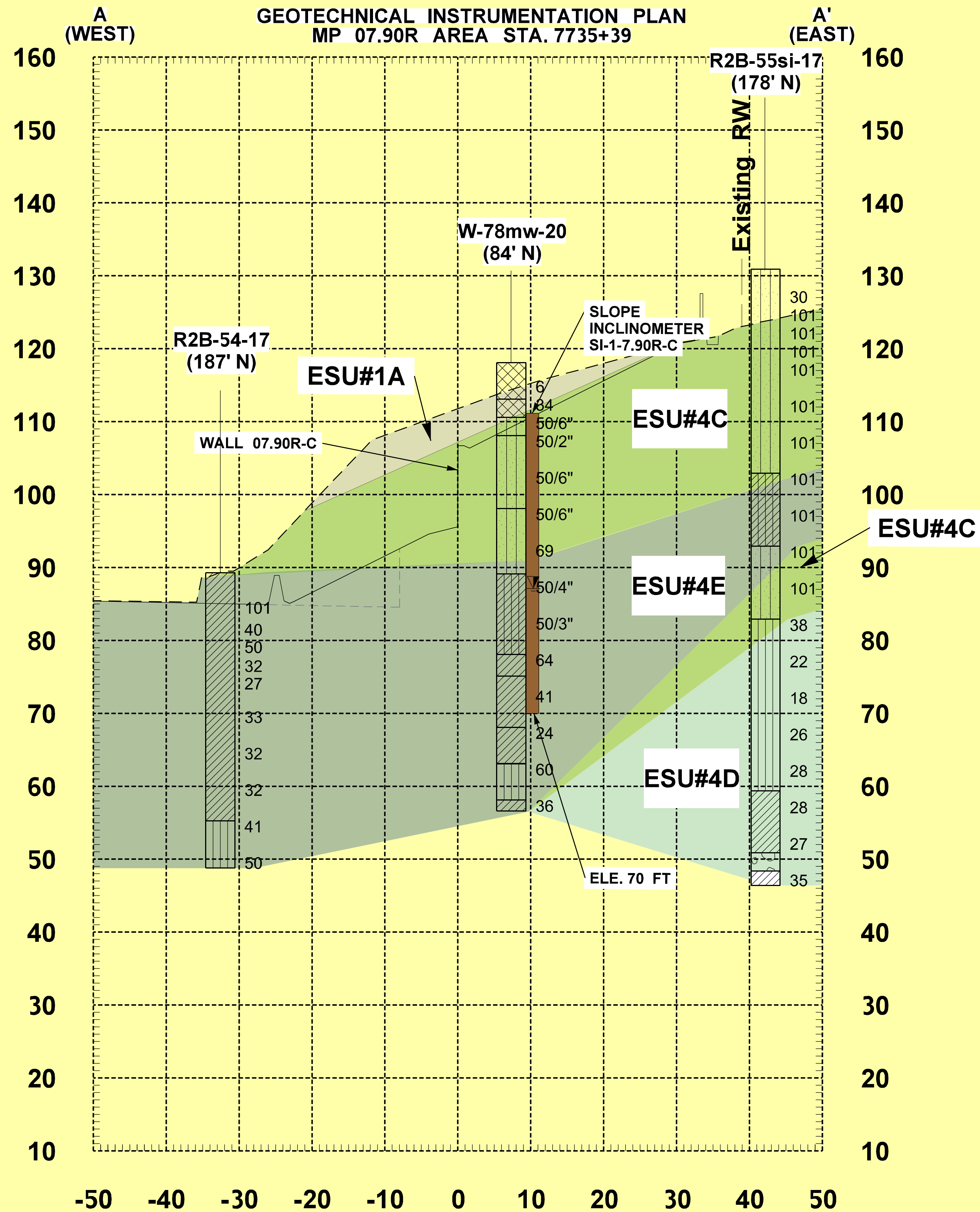
I-405; RENTON TO BELLEVUE WIDENING AND EXPRESS TOLL LANES PROJECT

GEOTECHNICAL INSTRUMENTATION PLAN
MP 07.90R AREA STA. 7732+24

PLAN REF NO

SHEET 6 OF 7 SHEETS

GEOTECHNICAL INSTRUMENTATION PLAN
MP 07.90R AREA STA. 7735+39



THE ESU STRATIFICATION HAVE BEEN INTERPRETED, INTERPOLATED BETWEEN EXPLORATIONS, AND EXTRAPOLATED BEYOND EXPLORATIONS FOR ENGINEERING DESIGN PURPOSES. THE STRATA MAY NOT REPRESENT ACTUAL SUBSURFACE CONDITIONS. SEE THE EXPLORATION LOGS FOR DETAILED SUBSURFACE CONDITIONS AT THE LOCATION EXPLORED.

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DATE	4/20/2021
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PROJ. ENGR.	T. WENTWORTH
REGIONAL ADM.	T. NETTLETON

REVISION | DATE | BY

REGION NO.	STATE	FED.AID PROJ.NO.
10	WASH	

JOB NUMBER

CONTRACT NO. | LOCATION NO.

P.E. STAMP BOX — DATE

P.E. STAMP BOX — DATE

Washington State Department of Transportation

FLATIRON LANE

wood.

I-405; RENTON TO BELLEVUE WIDENING AND EXPRESS TOLL LANES PROJECT

GEOTECHNICAL INSTRUMENTATION PLAN
MP 07.90R AREA STA. 7735+39

PLAN REF NO

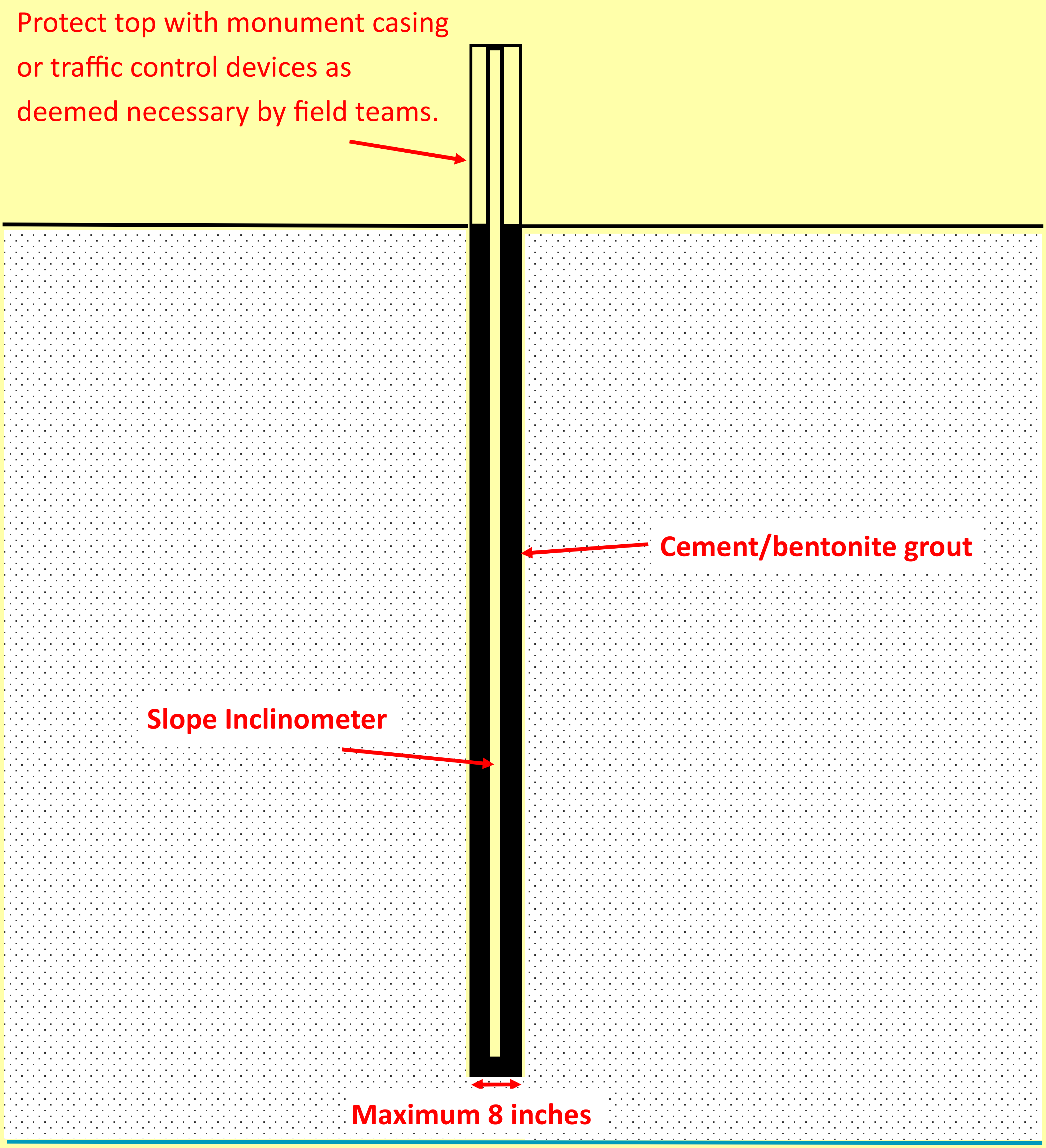
SHEET 7 OF 7 SHEETS

In Association with

Appendix B
Typical Slope Inclinometer Installation

Figure B-1: MP 07.90R Area

Slope Inclinometer Typical Installation



In Association with

Appendix C
Sample Report

Sample Reporting Format
Wall/Embankment ____________ Settlement Monitoring Report

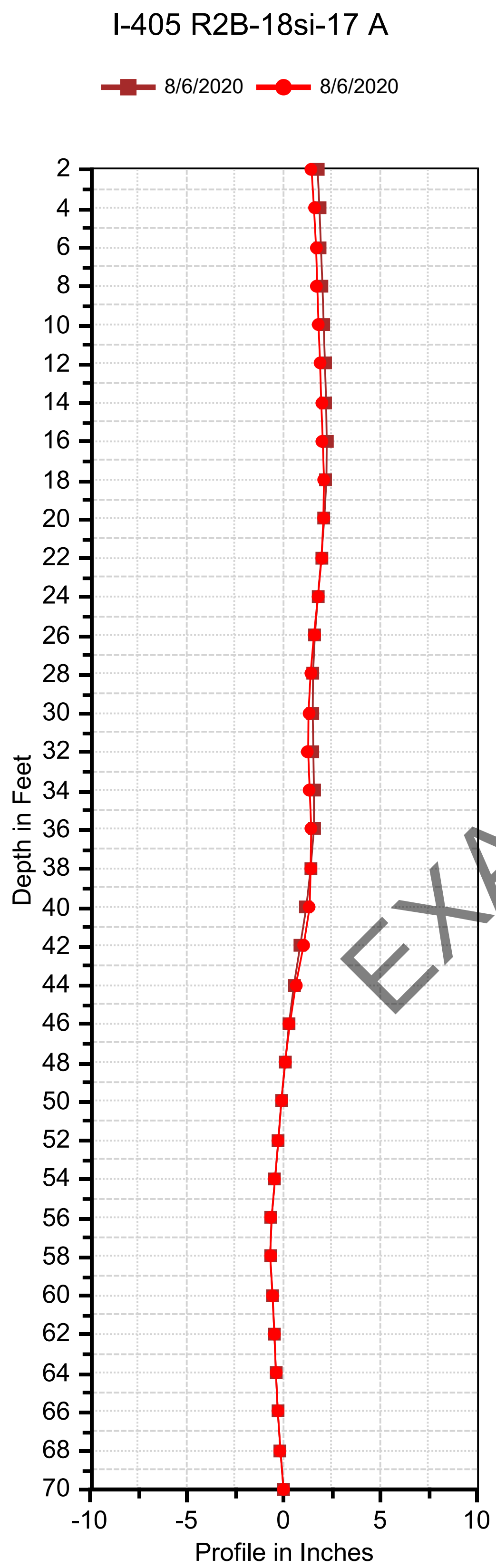
Surveyor:
Total Station: **S/N:**
Digital Level: **S/N:**
Time:
Temperature:
Weather Conditions:
Work Activity:

Basline Survey : MM/DD/YYYY				
Pt#	N	E	Elevation	Location

Delta Survey : MM/DD/YYYY				
Pt#	N	E	Elevation	Location

	1	2	3	4	5	6	7
Baseline	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Current	0.009	0.012	0.016	-0.008	-0.006	-0.001	0.002
Previous	0.011	0.013	0.017	0.003	0.003	0.009	0.012

Location and Elevation


I-405 R2B-18si-17 A
8/6/2020
8/6/2020
Depth in Feet
Profile in Inches
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
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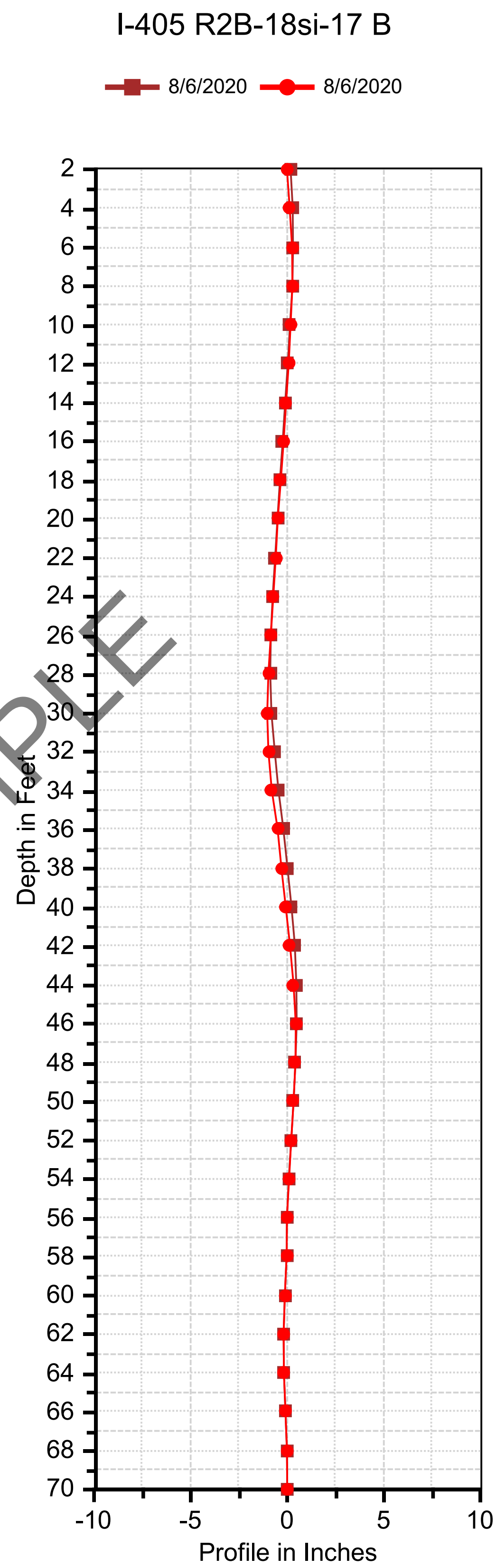
54
56
58
60
62
64
66
68
70
-10
-5
0
5
10


I-405 R2B-18si-17 B
8/6/2020
8/6/2020
Depth in Feet
Profile in Inches
2
4
6
8
10
12
14
16
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-10
-5
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In Association with

Appendix D
Data Sheets and Calibration Certificates for the Survey

FlatMesh™

Product Data Sheet:
FlatMesh Triaxial Tilt Node

The FlatMesh Triaxial Tilt Sensor Node is an extremely high precision and exceptionally stable three axis tilt sensor which reports its measurements through Senceive's FlatMesh wireless communications network to a FlatMesh Gateway.

Successfully used in many applications, including those measuring:

- Tunnel distortion
- Tunnel heave/settlement
- Embankment slippage
- Structural movement
- Rail track heave/settlement
- Rail trackbed cant and twist

Key features

- Integrated triaxial tilt sensor
- Extremely low noise performance
- Resolution of 0.0001° (0.0018 mm/m) and repeatability of ±0.0005° (±0.009 mm/m)
- Integrated long life battery
- 12-15 year battery life, including when acting as a relay node within the mesh communications network
- Integrated temperature sensor
- Versatile mounting options
- Waterproof to IP66 / IP67 / IP68
- Firmware is remotely upgradeable over the air via the gateway reducing costly site visits

FlatMesh Triaxial Tilt Node

Physical Specifications

Parameter	Value
Dimensions	90 x 90 x 60 mm
Dimensions including vent	90 x 96 x 60 mm
Total Mass	0.6 kg (approx.)
Housing Material	Die cast aluminium body
Internal Protection Marking	IP66 / IP67 IP68 (1 m for 24 hours)
Mounting Options	1/4” UNF holes in bottom, M4 blind holes in side Plates and brackets available for magnetic fixing, trackbed, stake and pole mounting, and many other applications
Operating Temperature Range	-40°C to +85°C

Internal Battery

Parameter	Value
Battery Type	Lithium Thionyl Chloride, non-rechargeable
Nominal Voltage	3.6 V
Nominal Capacity	19000 mAh
Typical Battery Life	12-15 years at 30 minute reporting intervals, including when acting as a relay node. Consult with Senceive for your application.

FlatMesh Triaxial Tilt Node

FlatMesh Radio Specifications

Parameter	Value
Communication Type	Proprietary FlatMesh v3 Mesh Networking Protocols IEEE 802.15.4 compliant
Frequency Band	2400 – 2485 MHz ISM Band
Maximum Transmit Power	6.5 dBm (EN 300 328 v1.8.1)
Maximum Permitted Antenna Gain	2.2 dBi
Range	Up to 300 m depending on the environment and fitted antenna Consult with Senceive for your application
RF Module	Senceive FM3Node

Tilt Sensor Specification

Parameter	Value
Resolution	0.0001° (0.00175 mm/m)
Repeatability (-IX variant)	±0.0005° (±0.0087 mm/m)
Repeatability (-IXH variant)	±0.0025° (±0.0436 mm/m)
Range	±90°

Certifications

- Tested to conformity with all the essential requirements of the Radio Equipment Directive 2014/53/EU and RoHS Directive 2011/65/EU
- FCC Grant of Equipment Authorization
- RCM (Australia and New Zealand)

FlatMesh Triaxial Tilt Node

Ordering Information and Accessories

Model	Description
FM3N-IX	**FlatMesh 3 Triaxial Inclinometer**
FM3N-IXH	**FlatMesh 3 Triaxial Inclinometer (High-g)**
FF-MP-S360	**Swivel mounting kit with 360-degree adjustment range** Screw directly to vertical walls
FF-MP-V	**Vertical mounting plate** Use U-bolts to fix to poles or stakes Use glue to fix to walls where drilling is not permitted (Order with FF-MP-S360)
FF-MP-RA	**Right angle mounting bracket** Screw to concrete tunnel linings and inclined walls (Order with FF-MP-S360)
FF-MP-T2	**Trackbed mounting plate kit**
FF-BK-xxxx **FF-BE**	**Tilt beam kit** See separate datasheet for more information
FA-FM-WPS	**Waterproof straight antenna** Overall node height 168 mm (approx) when fitted Maximum gain +1.1 dBi
FA-FM-LPS	**Waterproof low profile straight antenna** Minimum overall node height, perfect for trackbed and tight spots Overall node height 92 mm (approx) when fitted Maximum gain 0 dBi
FA-FM-ADJ	**Adjustable angle antenna** Flexible installation, perfect for use in tunnels and indoor environments Overall node height 202 mm (approx) when fitted and upright Overall node height 102 mm (approx) when fitted and at 90-degree angle Maximum gain +2 dBi
FC-NC	**Antenna cover kit** Use with FA-FM-LPS antenna Overall node height 96 mm (approx) when fitted

Trimble DiNi

DIGITAL LEVEL

The Trimble® DiNi® Digital Level is a digital height measurement sensor from Trimble's Integrated Surveying™ portfolio of products. The Trimble DiNi is a field-proven tool designed for any job site where fast and accurate height determination is required. Use the Trimble DiNi for applications such as precise leveling of flat and sloping surfaces, establishing the vertical component of grade and ground profiles, subsidence monitoring, and establishing the vertical component of control networks.

UNEQUALLED FOR PERFORMANCE IN THE FIELD

The Trimble DiNi is designed to perform optimally every day, whatever your surveying job. It is built rugged—with a dust- and waterproof rating of IP55—to take the tough conditions of the job site in its stride. A backlight in the screen and a light in the circular bubble keep you productive even when daylight gets low.

The DiNi will operate for three days without requiring a battery change, then when it does just recharge it as you would your Trimble GNSS system battery…the batteries are the same to ensure convenience and productivity.

When a job is complete, easily transfer data from the instrument to a computer by using a USB storage device; You don't have to carry your instrument in to the office.

EASY TO LEARN, EASY TO USE

The Trimble DiNi Digital Level demands the industry's smallest measurement field—just 30 cm of code rod. So you can measure greater change in height between the level and the rod in one setup, and save time. Additionally, the small measurement area:

- reduces the number of stations needed by up to 20% because the Trimble DiNi is less impacted by a rod hidden by vegetation or hilly terrain.
- makes leveling in low light conditions, for example, in tunnels, easier because only a very small part of the staff needs to be illuminated.
- ensures greater accuracy through less influence of refraction near the ground.

The large graphical display of the Trimble DiNi is also unique, and is complemented by the latest Trimble keyboard for easy operation. Crew members used to operating other Trimble systems will easily adapt to the Trimble DiNi.

TRIMBLE QUALITY AND ACCURACY FOR MEASURING WITH CONFIDENCE

The Trimble DiNi Digital Level is designed to support the rest of Trimble's Integrated Surveying portfolio. The Trimble DiNi interface is based on Trimble's other advanced and field-proven controllers for easy adoption of the instrument by your crews. Proven Optics by Carl Zeiss ensure the Trimble DiNi offers the highest precision and best resolution.

Measure with confidence, knowing that with the Trimble DiNi Digital Level, your crew will obtain the best quality results with the highest level of productivity.

Key Features

- Determine accurate height information via a quick and easy key press
- Eliminate errors and reduce rework with digital readings
- Enjoy effortless data transfer between instrument and office
- Measure to a measurement field of just 30 cm
- Level 60% faster than with conventional automatic leveling

Trimble DiNi DIGITAL LEVEL

PERFORMANCE SPECIFICATIONS

Accuracy .... DIN 18723, standard deviation height measuring per 1 km (3280.84 ft) of double leveling

Trimble DiNi 0.3 mm per km

Electronic measurement
- Invar precision bar code staff .... 0.3 mm (0.001 ft)
- Standard bar code staff .... 1.0 mm (0.004 ft)

Visual measurement .... 1.5 mm (0.005 ft)

Distance measurement .... with a 20 m (65.62 ft) sighting distance
- Invar precision bar code staff .... 20 mm (0.066 ft)
- Standard bar code staff .... 25 mm (0.082 ft)
- Visual measurements .... 0.2 m (0.656 ft)

Trimble DiNi 0.7 mm per km

Electronic measurement
- Invar precision bar code staff .... 0.7 mm (0.002 ft)
- Standard bar code staff .... 1.3 mm (0.004 ft)
- Visual measurement .... 2.0 mm (0.007 ft)

Distance measurement .... with a 20 m (65.62 ft) sighting distance
- Invar precision bar code staff .... 25 mm (0.082 ft)
- Standard bar code staff .... 30 mm (0.098 ft)
- Visual measurement .... 0.3 m (0.984 ft)

Range

Electronic measurement .... 1.5 m–100 m (4.92 ft–328.08 ft)

Visual measurement .... from 1.3 m (4.265 ft)

Electronic measurement

Trimble DiNi 0.3 mm per km

- Resolution height measurement.................. 0.01 mm / 0.0001 ft / 0.0001 in
- Resolution distance measurement .... 1 mm (0.003 ft)
- Measurement time .... 3 s

Trimble DiNi 0.7 mm per km

- Resolution height measurement.................. 0.1 mm / 0.001 ft / 0.001 in
- Resolution distance measurement .... 10 mm (0.033 ft)
- Measurement time .... 2 s

Horizontal Circle

Type of graduation .... 400 grads and 360 deg

Graduation interval .... 1 grad and 1 deg

Estimation to .... 0.1 grad and 0.1 deg

Measurement Programs

Trimble DiNi 0.3 mm per km

Standard programs .... Single measurement with and without stationing, stakeout, line leveling with intermediate sight and stakeout, line adjustment

Leveling methods[1] .... BF, BFFB, BFBF, BBFF, FBBF aBF, aBFFB, aBFBF, aBBFF, aFBBF

Trimble DiNi 0.7 mm per km

Standard programs .... Single measurement with and without stationing, stakeout, line leveling with intermediate sight and stakeout

Leveling methods .... BF, BFFB, aBF, aBFFB

ENVIRONMENTAL

Operating temperature .... −20 °C to +50 °C (−4 °F to 122 °F)

Dust- and waterproofing IP55

GENERAL SPECIFICATION

Telescope

Aperture .... 40 mm (0.131 ft)

Field of view at 100 m .... 2.2 m (7.217 ft)

Electronic measurement field .... 0.3 m (0.984 ft)

Magnification
- Trimble DiNi 0.3 mm per km .... 32 x
- Trimble DiNi 0.7 mm per km .... 26 x

Compensator

Inclination range .... ±15'

Setting accuracy
- Trimble DiNi 0.3 mm per km .... ±0.2"
- Trimble DiNi 0.7 mm per km .... ±0.5"

Circular level .... 8'/2 mm with Illumination

Display.................. Graphical, 240 x 160 pixels, monochrome with illumination

Keyboard .... 19-key alpha-numeric and 4-way arrow key for navigation\

Recording

Internal memory.................. up to 30 000 data lines

External memory .... USB Flash Drive support

Data transfer .... USB Interface for data transfer between DiNi and PC (means two way communication)

Real-time clock and temperature sensor
- Trimble DiNi 0.3 mm per km .... Recording of time or temperature
- Trimble DiNi 0.7 mm per km .... N.A.

Power supply
- Internal battery .... Li-Ion, 7.4 V / 2.4 Ah
- Operating time.................. 3 days working time without illumination

Weight (including battery) .... 3.5 kg (7.72 lb)

1 F = Foresight, B = Backsight, a = alternating

Certified quality in accordance with DIN ISO 9001/EN 29001.

Specifications subject to change without notice.

Contact your local Trimble Authorized Distribution Partner for more information

NORTH AMERICA
Trimble Inc.
10368 Westmoor Dr
Westminster CO 80021
USA

EUROPE
Trimble Germany GmbH
Am Prime Parc 11
65479 Raunheim
GERMANY

ASIA-PACIFIC
Trimble Navigation
Singapore Pty Limited
80 Marine Parade Road
#22-06, Parkway Parade
Singapore 449269
SINGAPORE

Certificate

TRIMBLE DiNi WITH SERIAL NUMBER 752150
COMPLIES WITH THESE SPECIFICATIONS:

HEIGHT MEASUREMENT

Accuracy *electronic measurements*
(Standard deviation for 1 km two-way levelling based on DIN 18723)

Precise levelling rod, coded scale:	0.3 mm (0.001 ft)
Engineer's folding staff, coded scale:	1.0 mm (0.003 ft)

Compensator

Working range of:	± 270 mgon (± 15')
Setting accuracy:	±0.06 mgon (± 0.2")

DISTANCE MEASUREMENT

Accuracy *electronic measurements*
Leveling mode
(0.3 m staff intercept, range 20 m)

Precise leveling rod, coded scale:	20 mm (0.066 ft)
Engineer's folding staff, coded scale	25 mm (0.082 ft)

MEASURING RANGE

Electronic measurement	**Range:**
Precise leveling rod, coded scale:	1.5 - 100 m (5 ft – 330 ft)
Engineer's folding staff, coded scale	1.5 - 100 m (5 ft – 330 ft)

Trimble instrument type Trimble DiNi has been tested and complies with the original specification. Tests have been conducted over established horizontal collimator height differences and baselines which have been calibrated with special Ni 002 levelling instrument by Carl Zeiss Jena in regular intervals. All procedures are documented in accordance with ISO 9001 issued by DQS, Germany.

L. Stiegler

Linda Stiegler, Inspector
January 21st, 2020 Jena, Germany

Trimble

Technical data

Height measurements

Standard deviation per km double run (ISO 17123-2):

Electronic measurement	**DNA03**	**DNA10**
with invar staff	0.3mm	0.9mm
with standard staff	1.0mm	1.5mm
Optical measurement	2.0mm	2.0mm

Distance measurement

Standard deviation	5mm/10m

Distance measuring range for electronic measurements

Staff lengths ≥ 3m	1.8m - 110m
Recommendation for 3m invar staffs	1.8m - 60m
Staff lengths = 2.7m	1.8m - 100m
Staff lengths = 1.82m/ 2m	1.8m - 60m
Measuring time single measure	typically 3 sec.

Telescope

Magnification	24x
Free objective diameter	36mm
Opening angle	2°
Field of view	3.5m at 100m
Min. target distance	0.6m
Multiplication constant	100
Addition constant	0

Level sensitivity

Circular level	8'/2mm

Compensator

Magnet damped pendulum compensator with electronic range control.

Slope angle		~± 10'
Centering accuracy	**DNA03**	**DNA10**
Standard deviation	0.3"	0.8"

Display

LC display	8 lines of 24 characters, 144 x 64 pixels
Lighting	economic/ permanent/ circular level only

Heating	on/off switch, sets in below -5°C

Dimensions

Instrument

Height (incl. hand grip)	168mm +/-5mm
Width	
on the side drives	240mm
instrument body	206mm
Length	210mm
Container	468 x 254 x 355mm (L x B x H)

Weight

incl. battery GEB111	2.85kg

Measured values corrections

Collimation error correction	automatically
Earth curvature correction	on/off switch; level probe with correction

Record

Internal storage	approx. 6000 measurements or about 1650 stations (BF)
Serial interface RS232	from "Measure & Record" in GSI-8/16-format
Data backup	PCMCIA-card (flash, SRAM), up to 32MB capacity

Temperature range

Storage:	-40°C - +70°C
Operation	-20°C - +50°C

Environmental conditions

Water and dust-proof	IP53 (acc. IEC60529)
Humidity	up to 95% humidity no condensation

Magnetic field sensitivity

Line-of-sight difference in horizontal constant magnetic field at a field strength of 0µT up to ±400µT [4 Gauss]. ≤ 1"

Battery powered

Batteries (NiMh)	**GEB111**	**GEB121**
Voltage	6V	6V
Capacity	1800mAh	3600mAh
Operating life DNA	12h	24h

Battery adapter GAD39 only for Alkaline batteries, 6 x LR6/AA/AM3, 1.5V

Trimble S7

TOTAL STATION

THE MOST PRODUCTIVE TOTAL STATION

The Trimble® S7 Total Station combines scanning, imaging and surveying into one powerful solution. Now you only need one instrument on the job site to perform all your data capture. Create 3D models, high accuracy visual site documentation, point clouds, and more using the Trimble S7, Trimble Access™ field software and Trimble Business Center office software.

The Trimble S7 is the ultimate system for efficient surveying, allowing you to adapt to any situation and increasing your productivity in the field. The combination of SureScan, Trimble VISION™, FineLock™ and DR Plus technology, along with many other features, means you'll be able to collect data faster and more accurately than ever before.

Integrated 3D Scanning

Save time in the field and in the office with Trimble SureScan technology. Now you have the flexibility to perform feature-rich scans every day. Efficiently capture the information you need to create digital terrain models (DTMs), perform volume calculations and make topographic measurements faster than with traditional surveying methods. SureScan technology enables you to collect and process data faster by focusing on collecting the right points, not just more points.

Improved Trimble VISION Technology

Trimble VISION technology gives you the power to direct your survey with live video images on the controller as well as create a wide variety of deliverables from collected imagery. Capture measurements to prisms or reflectorless with point-and-click efficiency via video. Quickly document your site and add notes directly to the pictures in the field to ensure you never miss that critical information. Back in the office, you can use your Trimble VISION data for measurements, or to process 360-degree panoramas and high dynamic range (HDR) images for even clearer deliverables.

Superior Accuracy with Trimble DR Plus

Trimble DR Plus range measurement technology provides extended range of Direct Reflex measurement without a prism. Now you can you measure further with fewer instrument set-ups and enhance your scanning performance. Trimble DR Plus, combined with the smooth and silent MagDrive™ servo technology, creates unmatched capability for quick measurements, without compromising on accuracy.

Manage Your Assets

Know where your total stations are 24 hours a day with Trimble Locate2Protect technology. See where your equipment is at any given time and get alerts if your instrument leaves a job site or experiences unexpected equipment shock or abuse.

Trimble InSphere™ Equipment Manager lets you view usage and keep up-to-date on firmware, software and maintenance requirements. With Trimble Locate2Protect and InSphere Equipment Manager, you can rest assured knowing your equipment is up-to-date and where it should be.

Powerful Field and Office Software

Choose from a variety of Trimble controllers operating the feature rich, intuitive Trimble Access field software. Streamlined workflows like Roads, Utilities and Pipelines guide crews through common project types, helping to get the job done faster with less distractions. Trimble Access workflows can also be customized to fit your needs.

Back in the office, trust Trimble Business Center to help you check, process and adjust your optical and GNSS data in one software solution.

Key Features

- Surveying, imaging and 3D scanning in one powerful solution
- Improved Trimble VISION technology for video robotic control, scene documentation and photogrammetric measurements
- Locate2Protect real-time equipment management
- Trimble DR Plus for long range and superior accuracy
- Intuitive Trimble Access Field Software
- Trimble Business Center Office Software for quick data processing
- Seamless integration with the Trimble V10 Imaging Rover and GNSS receivers

PERFORMANCE

Angle measurement

Sensor type .... Absolute encoder with diametrical reading
Accuracy (Standard deviation based on DIN 18723) .... 1" (0.3 mgon)
2" (0.6 mgon), 3" (1.0 mgon), or 5" (1.5 mgon)
Display (least count) .... 0.1" (0.01 mgon)
Automatic level compensator
- Type .... Centered dual-axis
- Accuracy .... 0.5" (0.15 mgon)
- Range .... ±5.4' (±100 mgon)

Distance measurement

Accuracy (ISO)
- Prism mode
  - Standard[1] .... 1 mm + 2 ppm (0.003 ft + 2 ppm)

Accuracy (RMSE)
- Prism mode
  - Standard .... 2 mm + 2 ppm (0.0065 ft + 2 ppm)
  - Tracking .... 4 mm + 2 ppm (0.013 ft + 2 ppm)
- DR mode
  - Standard .... 2 mm + 2 ppm (0.0065 ft + 2 ppm)
  - Tracking .... 4 mm + 2 ppm (0.013 ft + 2 ppm)
  - Extended range .... 10 mm + 2 ppm (0.033 ft + 2 ppm)

Measuring time

- Prism mode
  - Standard .... 1.2 sec
  - Tracking .... 0.4 sec
- DR mode
  - Standard .... 1–5 sec
  - Tracking .... 0.4 sec

Measurement range

- Prism mode[5, 6]
  - 1 prism .... 2,500 m (8,202 ft)
  - 1 prism Long Range mode .... 5,500 m (18,044 ft) (max. range)
- Shortest possible range .... 0.2 m (0.65 ft)
- DR mode

	Good (Good visibility, low ambient light)	Normal (Normal visibility, moderate unlight, some heat shimmer)	Difficult (Haze, object in direct sunlight, turbulence)
White card (90% reflective)[3]	1,300 m (4,265 ft)	1,300 m (4,265 ft)	1,200 m (3,937 ft)
Gray card (18% reflective)[3]	600 m (1,969 ft)	600 m (1,969 ft)	550 m (1,804 ft)

  - Reflective foil 20 mm .... 1,000 m (3,280 ft)
  - Shortest possible range .... 1 m (3.28 ft)
- DR Extended Range Mode
  - White Card (90% reflective)[3] .... 2,200 m

Scanning

- Range[2, 3] .... from 1 m up to 250 m (3.28 ft–820 ft)
- Speed[4] .... up to 15 points/sec
- Minimum point spacing .... 10 mm (0.032 ft)
- Standard deviation .... 1.5 mm @ ≤50 m (0.0049 ft @ ≤164 ft)
  - Single 3D point accuracy .... 10 mm @ ≤150 m (0.032 ft @ ≤492 ft)

EDM SPECIFICATIONS (DR PLUS)

Light source .... Pulsed Laser diode 905 nm; Laser class 1
Beam divergence
- Horizontal .... 2 cm/50 m (0.06 ft/164 ft)
- Vertical .... 4 cm/50 m (0.13 ft/164 ft)

SYSTEM SPECIFICATIONS

Leveling

Circular level in tribrach	8'/2 mm (8'/0.007 ft)
Electronic 2-axis level in the LC-display with a resolution of	0.3" (0.1 mgon)

Servo system

MagDrive servo technology	Integrated servo/angle sensor electromagnetic direct drive
Rotation speed	115 degrees/sec (128 gon/sec)
Rotation time Face 1 to Face 2	2.6 sec
Positioning speed180 degrees (200 gon)	2.6 sec
Clamps and slow motions	Servo-driven, endless fine adjustment

Centering

Centering system	Trimble 3-pin
Optical plummet	Built-in optical plummet
Magnification focusing distance	2.3×/0.5 m to infinity (1.6 ft to infinity)

Telescope

Magnification	30×
Aperture	40 mm (1.57 in)
Field of view at 100 m (328 ft)	2.6 m at 100 m (8.5 ft at 328 ft)
Focusing distance	1.5 m (4.92 ft) to infinity
Illuminated crosshair	Variable (10 steps)
Autofocus	Standard

Camera

Chip	Color Digital Image Sensor
Resolution	2048 x 1536 pixels
Focal length	23 mm (0.09 ft)
Depth of field	3 m to infinity (9.84 ft to infinity)
Field of view	16.5° x 12.3° (18.3 gon x 13.7 gon)
Digital zoom	4-step (1x, 2x, 4x, 8x)
Exposure	Spot, HDR, Automatic
Brightness	User-definable
Image storage	Up to 2048 x 1536 pixels
File format	JPEG
Compression ratio	User-definable
Video streaming[8]	5 frames/sec

Power supply

Internal battery	Rechargeable Li-Ion battery 11.1 V, 5.0 Ah
Operating time[9]	
One internal battery	Approx. 6.5 hours
Three internal batteries in multi-battery adapter	Approx. 20 hours
Robotic holder with one internal battery	Approx. 13.5 hours
Operating time for video robotic[9]	
One battery	5.5 hours
Three batteries in multi-battery adapter	17 hours

Weight and dimensions

Instrument	5.5 kg (11.57 lb)
Trimble CU controller	0.4 kg (0.88 lb)
Tribrach	0.7 kg (1.54 lb)
Internal battery	0.35 kg (0.77 lb)
Trunnion axis height	196 mm (7.71 in)

Other

Laser pointer coaxial	Laser class 2
Operating temperature	–20 °C to +50 °C (–4 °F to +122 °F)
Dust and water proofing	IP65
Communication	2.4 GHz, USB, Serial, Bluetooth®[10]
Security	Dual-layer password protection, Locate2Protect[11]

AUTOLOCK AND ROBOTIC SURVEYING

Autolock and Robotic Range[6]
- Passive prisms . . . . 500–700 m (1,640–2,297 ft)
- Trimble MultiTrack Target . . . . 800 m (2,625 ft)
- Trimble ActiveTrack 360 Target . . . . 500 m (1,640 ft)

Autolock pointing precision at 200 m (656 ft) (Standard deviation)[5]
- Passive prisms . . . . <2 mm (0.007 ft)
- Trimble MultiTrack Target . . . . <2 mm (0.007 ft)
- Trimble ActiveTrack 360 Target . . . . <2 mm (0.007 ft)

Shortest search distance . . . . 0.2 m (0.65 ft)

Type of radio internal/external . . . . 2.4 GHz frequency-hopping, spread-sprectrum radios

Search time (typical)[7] . . . . 2–10 sec

FINELOCK

Pointing precision at 300 m (980 ft)
- (standard deviation)[6] . . . . <1 mm (0.003 ft)
- Range to passive prisms (min–max)[6] . . . . 20 m–700 m (64 ft–2,297 ft)

Minimum spacing between prisms
- at 200 m (656 ft) . . . . 0.8 m (2.625 ft)

GPS SEARCH/GEOLOCK

GPS Search/GeoLock . . . . 360 degrees (400 gon) or defined horizontal and vertical search window

Solution acquisition time[12] . . . . 15–30 sec

Target re-acquisition time . . . . <3 sec

Range . . . . Autolock & Robotic range limits

1 Standard deviation according to ISO17123-4.
2 Target color, atmospheric conditions, and scanning angles will impact range.
3 Kodak Gray Card, Catalog number E1527795.
4 Target shape, texture, and color; grid size; and distance and angle to target; will impact speed.
5 Standard clear: No haze. Overcast or moderate sunlight with very light heat shimmer.
6 Range and accuracy depend on atmospheric conditions, size of prisms and background radiation.
7 Dependent on selected size of search window.
8 0.5 frames per second with remote operation.
9 The capacity in –20 °C (–5 °F) is 75% of the capacity at +20 °C (68 °F).
10 Bluetooth type approvals are country specific.
11 Functionality and availability dependent on region.
12 Solution acquisition time is dependent upon solution geometry and GPS position quality.

Specifications subject to change without notice.

CE Bluetooth®

Contact your local Trimble Authorized Distribution Partner for more information

NORTH AMERICA
Trimble Navigation Limited
10368 Westmoor Drive
Westminster CO 80021
USA

EUROPE
Trimble Germany GmbH
Am Prime Parc 11
65479 Raunheim
GERMANY

ASIA-PACIFIC
Trimble Navigation
Singapore Pty Limited
80 Marine Parade Road
#22-06, Parkway Parade
Singapore 449269
SINGAPORE

Certificate of Calibration

Make: Trimble Total Station
Model: S7 DR+ 1"
Serial Number: 37210575

This document certifies that the above instrument has been inspected and calibrated by the Frontier Precision Service Department. At the time of completion of this service, Frontier Precision certifies that the above stated product meets all factory specifications and tolerances for product parameters and performance of this product model.

All product calibration and specification parameters were tested and/or adjusted using applicable factory calibration jigs, optical collimation systems and electronic test equipment. All collimation systems have been properly checked and calibrated according to industry standard practices. All electronic test equipment used has had current calibration. All inspection and calibration procedures were performed using procedures and specifications for that product.

Date of Calibration: 4/17/2020

Next Recommended Calibration Date: 5/17/2021

Signed: Ken K Date: 4/17/2020

Name: KEN KRETCHMAR.

Title: Service Tech

AN EMPLOYEE-OWNED COMPANY

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Certificate of Calibration

Make: Trimble Total Station
Model: S7 DR+ 1"
Serial Number: 37220060

This document certifies that the above instrument has been inspected and calibrated by the Frontier Precision Service Department. At the time of completion of this service, Frontier Precision certifies that the above stated product meets all factory specifications and tolerances for product parameters and performance of this product model.

All product calibration and specification parameters were tested and/or adjusted using applicable factory calibration jigs, optical collimation systems and electronic test equipment. All collimation systems have been properly checked and calibrated according to industry standard practices. All electronic test equipment used has had current calibration. All inspection and calibration procedures were performed using procedures and specifications for that product.

Date of Calibration: 4/27/2020

Next Recommended Calibration Date: 5/27/2021

Signed: Ken K Date: 4/27/2020

Name: KEN KRETCHMAR.

Title: Service Tech

AN EMPLOYEE-OWNED COMPANY

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In Association with

Appendix E
Resumes of Key Staff

DAVID EVANS AND ASSOCIATES INC.

(Keith) Craig Moore, PLS, PSM | Survey Project Manager

Craig has more than 40 years of experience in the surveying field. His experience includes geometry control for fabrication and erection of precast concrete segments. Craig has held a supervisory position in the construction industry for 30 years. He has a record of success overseeing surveying on multimillion-dollar heavy civil, infrastructure, and commercial development projects for government and private-sector clients. His experience includes managing crews of up to 20 in highway/bridge, light rail, airport, high-rise, and a variety of other construction/land survey projects. Craig has a broad range of monitoring experience on Commercial and Heavy Civil projects, performing Monitoring on High Rise Structures, Ground Settlement, Temporary/Permanent Shoring, Formwork, Foundations, Utilities, and Bridges.

Experience

I-5/SR16 HOV Connector Design-Build Project, for WSDOT, Tacoma, Washington
As Survey Manager, Craig was responsible for subcontracts and survey on the highway and bridge Design-Build construction project. He managed implementation of Survey Controls, GPS, and Quality Control and Assurance. Craig was the Contractor's Task Force Lead on Roadway Design and worked on various Design Teams.

South 200th South Link S440 Design-Build Project, Sound Transit, SeaTac, Washington
As Survey Manager on the 1.6-mile Light Rail Design-Build project, Craig managed precast yard and site survey for the segmental span-by-span, balanced cantilever, and station facility on the light rail project at the SeaTac Airport. Tasks included Survey Controls for Structures, Settlement Monitoring of Utilities and Structures, and QA, QC oversight.

SR 520 Eastside Transit, HOV Design-Build Project, for WSDOT, Bellevue, Washington
Craig was the Survey Manager for this signature Design-Build project. The scope of this project involved over 2.5 miles of road widening to accommodate a new Eastbound HOV lane and wider shoulders, three large structural concrete lids and a new direct access interchange at Bellevue Way/108th Avenue for transit and HOV. Craig was responsible for contracts and management of survey including implementation of GPS, Machine Controls, Settlement Monitoring oversight and Quality Control and Assurance.

Education
Indian River Community College (Various AutoCAD and Surveying Classes) Fort, Pierce, FL, 1996-1998
American Traffic Safety Services Association: Certified Worksite Traffic Supervisor, 1995, Certified Traffic Control Supervisor, 1999
Dunwoody Industrial Institute, (Various AutoCAD and Surveying Classes) Minneapolis, MN, 1988-1989
Construction Surveying, Des Moines Area Community College, Des Moines, IA, 1979

Registration
Professional Surveyor and Mapper, Florida (LS 5981), 1999
Professional Land Surveyor, Washington (45167), 2008

Professional Affiliations
Florida Surveying and Mapping Society
Land Surveyors' Association of Washington
2011 Trustee - North Puget Sound Chapter
2012 Chapter President – North Puget Sound Chapter
2013 Trustee – North Puget Sound Chapter
2014 Chapter President – North Puget Sound Chapter
2015 Past President – North Puget Sound Chapter
2017 to current, Director – South Puget Sound Chapter

Years of Experience
40

Central Link Light Rail C755 and C410, for Sound Transit, Tukwila, Washington
Craig was Survey Manager on this project consisting of precast elevated segmental structures, at grade sections, roadway, station facility, plinths and track. The structure is a precast segmental design using two different procedures for erection of segments; span-by-span and balanced cantilevers. Craig was responsible for contracts and management of survey including performance of Substructure and Superstructure Precast erection, utilities, and Settlement Monitoring of structures and temporary shoring, and Quality Control and Assurance.

Memorial Causeway Bridge, for the Florida DOT, Clearwater, Florida
Craig was Survey Manager for this VECP project over the Intracoastal Waterway consisting of segmental cast-in-place twin bridges, nine spans in all; four balanced cantilever constructed with a cast in place traveler; five constructed on false work. Craig was responsible for management of survey including Substructure and Superstructure erection, utilities, and Settlement Monitoring of structures and temporary shoring, and Quality Control and Assurance.

I-4/St. John's River Design-Build Bridge, for the Florida DOT, Sanford, Florida
Craig was Survey Manager for the construction of a high level design-build bridge over the St. John's River northeast of Orlando. The Florida Bulb Tee superstructure is founded on concrete piling with cast-in-place footings, columns and caps. Each of the new bridges are 2,600 feet in length and have a maximum vertical clearance of 45 feet in the channel span.

Royal Park Temporary Bascule Design-Build Bridge, for the Florida DOT, West Palm Beach, Florida
Craig was the Survey Manager for the temporary 1,200-foot bascule bridge over the Intracoastal Waterway between West Palm Beach and The Town of Palm Beach. A steel frame was designed to support the bascule leafs on the temporary bridge. The 12-month schedule, included floating the bascule leaf components from the existing structure using the tides for lifting, eliminating the cost of renting a large water borne crane. The project was awarded the 2001 best design-build project in the civil sector (under $15 million) by the Design-Build Institute of America. As Surveyor Manager, Craig performed survey calculations, layout, and shoring and settlement monitoring.

Evans Crary Sr. Bridge, for the Florida DOT, Stuart, Florida
Craig was Survey Manager for this twin precast segmental structure that spanned the St. Lucie River. The bridges are 3,000 feet long, 50 feet wide with 180-foot spans, 17 in total, and a vertical clearance of 65 feet. Due to site conditions and a compressed schedule, a VECP was submitted to FDOT to change from balanced cantilever to span-by-span construction. As Surveyor Manager, Craig performed survey calculations, layout, shoring, and settlement monitoring.

Indiantown Road Bascule Bridge, for the Florida DOT, Jupiter, Florida
Craig was the Survey Manager and Traffic Control Supervisor for these twin bascule bridge structures over the Intracoastal Waterway. Features include 24-inch and 30-inch concrete piling foundations, and Florida Bulb T girder approaches with cast-in-place decks. Temporary and permanent MSE walls, sheet piling, asphalt and base completed the road work package. As Surveyor Manager, Craig performed survey calculations, layout, shoring, and settlement monitoring.

U.S. 41 Widening, for the Florida DOT, Sarasota, Florida
Craig was Project Surveyor on this widening project that consisted of 3 multi span flat slab bridges over Phillippi Creek. Other work included 3 miles of roadway with curb and gutter, asphalt and base widening, riprap, and signalization.

Natchez Trace Parkway Bridge, for the U.S. Department of Transportation (FHWA), Franklin, Tennessee
As the Project Surveyor, Craig was responsible for the Geometry Control on this double arch precast segmental bridge located over Route 96 in Tennessee's Natchez Trace Parkway. This project was featured in the July 26, 1999, issue of Engineering News-Record's 125 years Top Projects as the 1993 entry.

Denver International Airport Central Cores for Concourses A, B & C, City of Denver, Dept. of Aviation, Denver, Colorado
Craig was Field Engineer and Surveyor on the DIA Cores and Tunnels contract. The project consisted of three concourse structures connected with below-grade AGTS tunnels. It was the 1995 entry in the Engineering News-Record's July 26, 1999 issue on 125 Years Top Projects.

Dain Rauscher / Neiman Marcus Plaza (presently RBC Plaza), for Brookfield Office Properties, Minneapolis, Minnesota
Craig was the Surveyor on the 40-story retail and office tower in downtown Minneapolis. This one million-square-foot development provides a thirty five-story, 690,000 sq. ft. office building on a five-story, 240,000 sq. ft. retail podium. As the Surveyor, Craig performed survey layout, shoring monitoring, and quantity updates.

Principal Financial Building, for Principal Financial Group, Des Moines, Iowa
Craig was Field Engineer for the 12-story building in downtown Des Moines. Two skyways and two tunnels connect the new building to two adjacent buildings. As field engineer, Craig performed survey layout, shoring monitoring, and quantity updates.

Various Consulting Survey Firms in Iowa, Nebraska, and Minnesota
Early in his career, Craig worked for Consulting Survey firms on a multitude of public and private sector projects, developing plats, sectional, boundary, settlement monitoring, and plat surveying. His construction staking experience includes subdivision, commercial developments, and mainline pipeline and stations.